

This listing of claims replaces all prior versions, and listings of claims in the instant application:

Listing of Claims:

1. (Currently Amended) A method for arithmetic expression optimization, comprising:

validating at least one input stack associated with a first instruction configured to operate on at least one operand of a first type, each of said at least one input stack associated with an input instruction of said first instruction, each input stack representing the state of an operand stack associated with an input instruction upon execution of said input instruction;

optimizing converting said first instruction to a second instruction configured to operate on at least one operand of a second type, said second type smaller than said first type, said optimizing converting based at least in part on the relative size of said first type and said second type, wherein said second instruction is different from said first instruction; and

matching said second type with an operand type of at least one operand in said at least one input stack associated with said second instruction, said matching comprising changing the type of instructions in a chain of instructions to equal said second type if said operand type is less than said second type, said chain bounded by said second instruction and a third instruction that is the source of said at least one operand.

2. (Original) The method of claim 1 wherein said first instruction is arithmetic.

3. (Original) The method of claim 1 wherein said first instruction comprises a non-arithmetic, type-sensitive instruction.

4. (Currently Amended) The method of claim 1, further comprising repeating said validating, said ~~optimizing~~ converting and said matching for instructions that comprise a program.

5. (Original) The method of claim 1, further comprising linking each instruction to input instructions in all control paths.

6. (Original) The method of claim 1 wherein
said first instruction is defined for a first processor having a first base; and
said second instruction is defined for a second processor having a second base.

7. (Original) The method of claim 6 wherein
said first processor comprises a Java™ Virtual Machine; and
said second processor comprises a Java Card™ Virtual Machine.

8. (Original) The method of claim 6 wherein
said first processor comprises a 32-bit processor;
and
said second processor comprises a resource-constrained 16-bit processor.

9. (Original) The method of claim 1 wherein
said at least one input stack comprises a plurality of input stacks, said plurality of input stacks further

comprising a first input stack and a second input stack;
and

said validating further comprises comparing operand types of corresponding entries in said first input stack and said second input stack.

10. (Original) The method of claim 9 wherein said comparing further comprises indicating an error if the types of at least said first at least one stack entry and said second at least one stack entry are not equivalent.

11. (Currently Amended) The method of claim 1 wherein said optimizing converting further comprises:

setting said second type to a smallest type;

setting said second type to the type of an operand in said at least one input stack if said smallest type is less than said type of said operand; and

setting said second type to a type that is larger than said smallest type if said smallest type is greater than said type of said operand, if said operand has potential overflow, if said second instruction is sensitive to overflow and if said second type is less than said first type.

12. (Original) The method of claim 11 wherein said smallest type is the smallest type supported by a target processor.

13. (Currently Amended) The method of claim 11 wherein said smallest type is the smallest type determined during a previous pass of said optimizing converting.

14. (Original) The method of claim 1 wherein

said third instruction is not a source instruction;
and

said changing further comprises:

recursively examining input instructions until said
third instruction is obtained; and

setting the type of said third instruction to equal
said second type.

15. (Original) The method of claim 1 wherein
said third instruction comprises a source
instruction; and

said changing further comprises:

recursively examining input instructions until
said third instruction is obtained;

setting the type of said third instruction to
equal said second type; and

repeating said changing for each input
instruction of said third instruction.

16. (Original) The method of claim 1, further comprising
recording conversion results, said recording comprising:

determining potential overflow associated with said
second instruction; and

generating an output stack based at least in part on
execution of said second instruction.

17. (Original) The method of claim 16 wherein said
determining further comprises:

indicating said second instruction has potential
overflow if said second type does not equal said first
type, if said second instruction does not remove potential
overflow, and if said second instruction creates potential
overflow; and

indicating said second instruction has potential overflow if said second type does not equal said first type, if said second instruction does not remove potential overflow, if said second instruction does not create potential overflow, if said second instruction propagates potential overflow, and if at least one operand in said at least one input stack has potential overflow.

18. (Original) The method of claim 17 wherein said determining further comprises:

indicating said second instruction has potential overflow if said second type does not equal said first type, if said second instruction does not remove potential overflow, and if overflow is possible based at least in part on the type of said second instruction and the relationship between said first type and said second type; and

indicating said second instruction has potential overflow if said second type does not equal said first type, if said second instruction does not remove potential overflow, if overflow is not possible based at least in part on the type of said second instruction and the relationship between said first type and said second type, if said second instruction propagates potential overflow, and if at least one operand in said at least one input stack has potential overflow.

19. (Original) The method of claim 16 wherein said generating further comprises:

creating a new output stack based at least in part on one of said at least one input stack;

updating said new output stack based at least in part on operation of said second instruction; and

indicating another instruction conversion pass is required if said new stack does not equal a previous output stack.

20. (Currently Amended) A method for arithmetic expression optimization, comprising:

step for validating at least one input stack associated with a first instruction configured to operate on at least one operand of a first type, each of said at least one input stack associated with an input instruction of said first instruction, each input stack representing the state of an operand stack associated with an input instruction upon execution of said input instruction;

step for ~~optimizing~~ converting said first instruction to a second instruction configured to operate on at least one operand of a second type, said second type smaller than said first type, said ~~optimizing~~ converting based at least in part on the relative size of said first type and said second type, wherein said second instruction is different from said first instruction; and

step for matching said second type with an operand type of at least one operand in said at least one input stack associated with said second instruction, said matching comprising changing the type of instructions in a chain of instructions to equal said second type if said operand type is less than said second type, said chain bounded by said second instruction and a third instruction that is the source of said at least one operand.

21. (Original) The method of claim 20 wherein said first instruction is arithmetic.

22. (Original) The method of claim 20 wherein said first instruction comprises a non-arithmetic, type-sensitive instruction.

23. (Currently Amended) The method of claim 20, further comprising step for repeating said validating, said ~~optimizing~~ converting and said matching for instructions that comprise a program.

24. (Original) The method of claim 20, further comprising step for linking each instruction to input instructions in all control paths.

25. (Original) The method of claim 20 wherein
said first instruction is defined for a first processor having a first base; and
said second instruction is defined for a second processor having a second base.

26. (Original) The method of claim 25 wherein
said first processor comprises a Java™ Virtual Machine; and
said second processor comprises a Java Card™ Virtual Machine.

27. (Original) The method of claim 25 wherein
said first processor comprises a 32-bit processor;
and
said second processor comprises a resource-constrained 16-bit processor.

28. (Original) The method of claim 20 wherein
said at least one input stack comprises a plurality of input stacks, said plurality of input stacks further

comprising a first input stack and a second input stack;
and

said validating further comprises comparing operand
types of corresponding entries in said first input stack
and said second input stack.

29. (Original) The method of claim 28 wherein said step
for comparing further comprises step for indicating an error if
the types of at least said first at least one stack entry and
said second at least one stack entry are not equivalent.

30. (Currently Amended) The method of claim 20 wherein
said ~~optimizing~~ converting further comprises:

step for setting said second type to a smallest type;
step for setting said second type to the type of an
operand in said at least one input stack if said smallest
type is less than said type of said operand; and

step for setting said second type to a type that is
larger than said smallest type if said smallest type is
greater than said type of said operand, if said operand
has potential overflow, if said second instruction is
sensitive to overflow and if said second type is less than
said first type.

31. (Original) The method of claim 30 wherein said
smallest type is the smallest type supported by a target
processor.

32. (Currently Amended) The method of claim 30 wherein
said smallest type is the smallest type determined during a
previous pass of said ~~optimizing~~ converting.

33. (Original) The method of claim 20 wherein

said third instruction is not a source instruction;
and

said step for changing further comprises:

step for recursively examining input
instructions until said third instruction is
obtained; and

step for setting the type of said third
instruction to equal said second type.

34. (Original) The method of claim 20 wherein
said third instruction comprises a source
instruction; and

said step for changing further comprises:

step for recursively examining input
instructions until said third instruction is
obtained;

step for setting the type of said third
instruction to equal said second type; and

step for repeating said changing for each input
instruction of said third instruction.

35. (Original) The method of claim 20, further
comprising step for recording conversion results, said
recording comprising:

step for determining potential overflow associated
with said second instruction; and

step for generating an output stack based at least in
part on execution of said second instruction.

36. (Original) The method of claim 35 wherein said step
for determining further comprises:

step for indicating said second instruction has
potential overflow if said second type does not equal said
first type, if said second instruction does not remove

potential overflow, and if said second instruction creates potential overflow; and

step for indicating said second instruction has potential overflow if said second type does not equal said first type, if said second instruction does not remove potential overflow, if said second instruction does not create potential overflow, if said second instruction propagates potential overflow, and if at least one operand in said at least one input stack has potential overflow.

37. (Original) The method of claim 36 wherein said step for determining further comprises:

step for indicating said second instruction has potential overflow if said second type does not equal said first type, if said second instruction does not remove potential overflow, and if overflow is possible based at least in part on the type of said second instruction and the relationship between said first type and said second type; and

step for indicating said second instruction has potential overflow if said second type does not equal said first type, if said second instruction does not remove potential overflow, if overflow is not possible based at least in part on the type of said second instruction and the relationship between said first type and said second type, if said second instruction propagates potential overflow, and if at least one operand in said at least one input stack has potential overflow.

38. (Original) The method of claim 35 wherein said step for generating further comprises:

step for creating a new output stack based at least in part on one of said at least one input stack;

step for updating said new output stack based at least in part on operation of said second instruction; and
step for indicating another instruction conversion pass is required if said new stack does not equal a previous output stack.

39. (Currently Amended) A program storage device readable by a machine, embodying a program of instructions executable by the machine to perform a method for arithmetic expression optimization, the method comprising:

validating at least one input stack associated with a first instruction configured to operate on at least one operand of a first type, each of said at least one input stack associated with an input instruction of said first instruction, each input stack representing the state of an operand stack associated with an input instruction upon execution of said input instruction;

optimizing converting said first instruction to a second instruction configured to operate on at least one operand of a second type, said second type smaller than said first type, said optimizing converting based at least in part on the relative size of said first type and said second type, wherein said second instruction is different from said first instruction; and

matching said second type with an operand type of at least one operand in said at least one input stack associated with said second instruction, said matching comprising changing the type of instructions in a chain of instructions to equal said second type if said operand type is less than said second type, said chain bounded by said second instruction and a third instruction that is the source of said at least one operand.

40. (Original) The program storage device of claim 39 wherein said first instruction is arithmetic.

41. (Original) The program storage device of claim 39 wherein said first instruction comprises a non-arithmetic, type-sensitive instruction.

42. (Currently Amended) The program storage device of claim 39, said method further comprising repeating said validating, said ~~optimizing~~ converting and said matching for instructions that comprise a program.

43. (Original) The program storage device of claim 39, said method further comprising linking each instruction to input instructions in all control paths.

44. (Original) The program storage device of claim 39 wherein

said first instruction is defined for a first processor having a first base; and

said second instruction is defined for a second processor having a second base.

45. (Original) The program storage device of claim 44 wherein

said first processor comprises a Java™ Virtual Machine; and

said second processor comprises a Java Card™ Virtual Machine.

46. (Original) The program storage device of claim 44 wherein

said first processor comprises a 32-bit processor;
and

said second processor comprises a resource-constrained 16-bit processor.

47. (Original) The program storage device of claim 39 wherein

said at least one input stack comprises a plurality of input stacks, said plurality of input stacks further comprising a first input stack and a second input stack; and

said validating further comprises comparing operand types of corresponding entries in said first input stack and said second input stack.

48. (Original) The program storage device of claim 47 wherein said comparing further comprises indicating an error if the types of at least said first at least one stack entry and said second at least one stack entry are not equivalent.

49. (Currently Amended) The program storage device of claim 39 wherein said ~~optimizing~~ converting further comprises:

setting said second type to a smallest type;

setting said second type to the type of an operand in said at least one input stack if said smallest type is less than said type of said operand; and

setting said second type to a type that is larger than said smallest type if said smallest type is greater than said type of said operand, if said operand has potential overflow, if said second instruction is sensitive to overflow and if said second type is less than said first type.

50. (Original) The program storage device of claim 49 wherein said smallest type is the smallest type supported by a target processor.

51. (Currently Amended) The program storage device of claim 49 wherein said smallest type is the smallest type determined during a previous pass of said ~~optimizing~~ converting.

52. (Original) The program storage device of claim 39 wherein

said third instruction is not a source instruction;
and

said changing further comprises:

recursively examining input instructions until said third instruction is obtained; and

setting the type of said third instruction to equal said second type.

53. (Original) The program storage device of claim 39 wherein

said third instruction comprises a source instruction; and

said changing further comprises:

recursively examining input instructions until said third instruction is obtained;

setting the type of said third instruction to equal said second type; and

repeating said changing for each input instruction of said third instruction.

54. (Original) The program storage device of claim 39, further comprising recording conversion results, said recording comprising:

determining potential overflow associated with said second instruction; and

generating an output stack based at least in part on execution of said second instruction.

55. (Original) The program storage device of claim 54 wherein said determining further comprises:

indicating said second instruction has potential overflow if said second type does not equal said first type, if said second instruction does not remove potential overflow, and if said second instruction creates potential overflow; and

indicating said second instruction has potential overflow if said second type does not equal said first type, if said second instruction does not remove potential overflow, if said second instruction does not create potential overflow, if said second instruction propagates potential overflow, and if at least one operand in said at least one input stack has potential overflow.

56. (Original) The program storage device of claim 55 wherein said determining further comprises:

indicating said second instruction has potential overflow if said second type does not equal said first type, if said second instruction does not remove potential overflow, and if overflow is possible based at least in part on the type of said second instruction and the relationship between said first type and said second type; and

indicating said second instruction has potential overflow if said second type does not equal said first type, if said second instruction does not remove potential overflow, if overflow is not possible based at least in part on the type of said second instruction and the relationship between said first type and said second type, if said second instruction propagates potential overflow,

and if at least one operand in said at least one input stack has potential overflow.

57. (Original) The program storage device of claim 54 wherein said generating further comprises:

creating a new output stack based at least in part on one of said at least one input stack;

updating said new output stack based at least in part on operation of said second instruction; and

indicating another instruction conversion pass is required if said new stack does not equal a previous output stack.

58. (Currently Amended) An apparatus for arithmetic expression optimization, comprising:

means for validating at least one input stack associated with a first instruction configured to operate on at least one operand of a first type, each of said at least one input stack associated with an input instruction of said first instruction, each input stack representing the state of an operand stack associated with an input instruction upon execution of said input instruction;

means for optimizing converting said first instruction to a second instruction configured to operate on at least one operand of a second type, said second type smaller than said first type, said optimizing converting based at least in part on the relative size of said first type and said second type, wherein said second instruction is different from said first instruction; and

means for matching said second type with an operand type of at least one operand in said at least one input stack associated with said second instruction, said matching comprising changing the type of instructions in a chain of instructions to equal said second type if said

operand type is less than said second type, said chain bounded by said second instruction and a third instruction that is the source of said at least one operand.

59. (Original) The apparatus of claim 58 wherein said first instruction is arithmetic.

60. (Original) The apparatus of claim 58 wherein said first instruction comprises a non-arithmetic, type-sensitive instruction.

61. (Currently Amended) The apparatus of claim 58, further comprising means for repeating said validating, said ~~optimizing~~ converting and said matching for instructions that comprise a program.

62. (Original) The apparatus of claim 58, further comprising means for linking each instruction to input instructions in all control paths.

63. (Original) The apparatus of claim 58 wherein
said first instruction is defined for a first processor having a first base; and
said second instruction is defined for a second processor having a second base.

64. (Original) The apparatus of claim 63 wherein
said first processor comprises a Java™ Virtual Machine; and
said second processor comprises a Java Card™ Virtual Machine.

65. (Original) The apparatus of claim 63 wherein

said first processor comprises a 32-bit processor;
and

said second processor comprises a resource-
constrained 16-bit processor.

66. (Original) The apparatus of claim 58 wherein
said at least one input stack comprises a plurality
of input stacks, said plurality of input stacks further
comprising a first input stack and a second input stack;
and

said means for validating further comprises means for
comparing operand types of corresponding entries in said
first input stack and said second input stack.

67. (Original) The apparatus of claim 66 wherein said
means for comparing further comprises means for indicating an
error if the types of at least said first at least one stack
entry and said second at least one stack entry are not
equivalent.

68. (Currently Amended) The apparatus of claim 58
wherein said means for ~~optimizing~~ converting further comprises:
means for setting said second type to a smallest
type;

means for setting said second type to the type of an
operand in said at least one input stack if said smallest
type is less than said type of said operand; and

means for setting said second type to a type that is
larger than said smallest type if said smallest type is
greater than said type of said operand, if said operand
has potential overflow, if said second instruction is
sensitive to overflow and if said second type is less than
said first type.

69. (Original) The apparatus of claim 68 wherein said smallest type is the smallest type supported by a target processor.

70. (Currently Amended) The apparatus of claim 68 wherein said smallest type is the smallest type determined during a previous pass of said ~~optimizing~~ converting.

71. (Original) The apparatus of claim 58 wherein said third instruction is not a source instruction; and
said means for changing further comprises:
means for recursively examining input instructions until said third instruction is obtained; and
means for setting the type of said third instruction to equal said second type.

72. (Original) The apparatus of claim 58 wherein said third instruction comprises a source instruction; and
said means for changing further comprises:
means for recursively examining input instructions until said third instruction is obtained;
means for setting the type of said third instruction to equal said second type; and
means for repeating said changing for each input instruction of said third instruction.

73. (Original) The apparatus of claim 58, further means for comprising recording conversion results, said recording comprising:

means for determining potential overflow associated with said second instruction; and

means for generating an output stack based at least in part on execution of said second instruction.

74. (Original) The apparatus of claim 73 wherein said means for determining further comprises:

means for indicating said second instruction has potential overflow if said second type does not equal said first type, if said second instruction does not remove potential overflow, and if said second instruction creates potential overflow; and

means for indicating said second instruction has potential overflow if said second type does not equal said first type, if said second instruction does not remove potential overflow, if said second instruction does not create potential overflow, if said second instruction propagates potential overflow, and if at least one operand in said at least one input stack has potential overflow.

75. (Original) The apparatus of claim 74 wherein said determining further comprises:

means for indicating said second instruction has potential overflow if said second type does not equal said first type, if said second instruction does not remove potential overflow, and if overflow is possible based at least in part on the type of said second instruction and the relationship between said first type and said second type; and

means for indicating said second instruction has potential overflow if said second type does not equal said first type, if said second instruction does not remove potential overflow, if overflow is not possible based at least in part on the type of said second instruction and the relationship between said first type and said second type, if said second instruction propagates potential

overflow, and if at least one operand in said at least one input stack has potential overflow.

76. (Original) The apparatus of claim 73 wherein said means for generating further comprises:

means for creating a new output stack based at least in part on one of said at least one input stack;

means for updating said new output stack based at least in part on operation of said second instruction; and

means for indicating another instruction conversion pass is required if said new stack does not equal a previous output stack.

77. (Currently Amended) A method of using an application software program including arithmetic expression optimization of at least one instruction targeted to a processor, the method comprising:

receiving the software program on said processor, said software program optimized according to a method comprising:

validating at least one input stack associated with a first instruction configured to operate on at least one operand of a first type, each of said at least one input stack associated with an input instruction of said first instruction, each input stack representing the state of an operand stack associated with an input instruction upon execution of said input instruction;

optimizing converting said first instruction to a second instruction configured to operate on at least one operand of a second type, said second type smaller than said first type, said ~~optimizing~~ converting based at least in part on the relative size of said first type and said second type, wherein

said second instruction is different from said first instruction; and

matching said second type with an operand type of at least one operand in said at least one input stack associated with said second instruction, said matching comprising changing the type of instructions in a chain of instructions to equal said second type if said operand type is less than said second type, said chain bounded by said second instruction and a third instruction that is the source of said at least one operand; and

executing said at least one instruction on said processor.

78. (Currently Amended) A smart card having a microcontroller embedded therein, said microcontroller configured to execute a virtual machine, the virtual machine capable of executing a software application comprising a plurality of previously optimized instructions, the instructions optimized by a method comprising:

validating at least one input stack associated with a first instruction configured to operate on at least one operand of a first type, each of said at least one input stack associated with an input instruction of said first instruction, each input stack representing the state of an operand stack associated with an input instruction upon execution of said input instruction;

~~optimizing~~ converting said first instruction to a second instruction configured to operate on at least one operand of a second type, said second type smaller than said first type, said ~~optimizing~~ converting based at least in part on the relative size of said first type and said second type, wherein said second instruction is different from said first instruction; and

matching said second type with an operand type of at least one operand in said at least one input stack associated with said second instruction, said matching comprising changing the type of instructions in a chain of instructions to equal said second type if said operand type is less than said second type, said chain bounded by said second instruction and a third instruction that is the source of said at least one operand.